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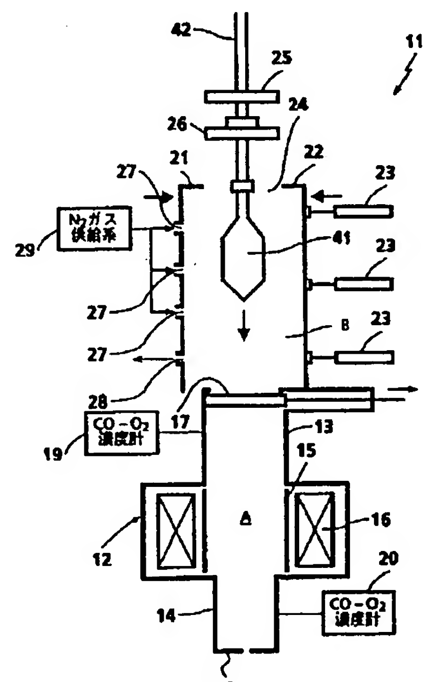
(54)【発明の名称】　光ファイバの線引炉

(57)【要約】

【目的】　装置の省スペース化及び光ファイバ母材の交換作業の短縮化、光ファイバの高品質化を図った光ファイバの線引炉を提供する。

【構成】　内部にヒーター16が設けられて連続的に流入される窒素ガスで満たされる線引室Ａを有し、その線引室Ａの入口部13から挿入される光ファイバ母材41を加熱溶融して出口部14から光ファイバ43を線引きする光ファイバの線引炉11において、線引室Ａに連通する光ファイバ母材収納室Ｂを着脱自在に設けると共に線引室Ａと収納室Ｂとの間にシャッター17を設け、収納室Ｂには窒素ガスを供給する窒素ガス供給系19を接続する一方、線引室Ａには炭素及び酸素の濃度変化を検出する濃度計19，20を接続し、また、収納室Ｂには加熱された光ファイバ母材41を窒素ガス供給系19によって強制冷却可能とする。



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【特許請求の範囲】

【請求項1】　入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には不活性流体を供給する不活性流体供給系を接続したことを特徴とする光ファイバの線引炉。

【請求項2】　入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には不活性流体を供給する不活性流体供給系を接続する一方、前記線引室には炭素及び酸素の濃度変化を検出する濃度計を接続したことを特徴とする光ファイバの線引炉。

【請求項3】　入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には加熱された前記光ファイバ母材を冷却する冷却装置を装着したことを特徴とする光ファイバの線引炉。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は大型の光ファイバ母材から線径変動の少ない光ファイバを得ることができる光ファイバ線引炉に関する。

【0002】

【従来の技術】従来より光ファイバ母材（以下、単に母材とも称す）を加熱溶融し、線引きして光ファイバを得るために光ファイバ線引炉が用いられる。図9に従来の光ファイバの線引炉を表す概略を示す。

【0003】図9に示すように、線引炉101において、炉本体102には入口部103と出口部104が形成され、内部に加熱器105が取付けられている。この炉本体102の上部には収納室106が設けられ、この収納室106と炉本体102の入口部103との間には両者を連通、且つ、遮断可能な開閉器107が取付けられている。収納室106は上部に光ファイバ母材200を挿入するための開閉蓋108が取付けられると共に、

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ガスの給排を行う供給口109及び排出口110が形成され、供給口109にはこの収納室106内へ不活性ガスを供給するガス供給系111が接続され、排出口110には逆止弁112が取付けられている。また、炉本体102の出口部104には光ファイバ201を線引きする小孔を有する開閉蓋113が取付けられている。

【0004】而して、かかる線引炉101を用いて光ファイバ線引作業を行う場合、まず、開閉器107によって収納室106と入口部103とを遮断し、この収納室106内に光ファイバ母材200を挿入して開閉蓋108を閉じた密閉状態とする。そして、ガス供給系111により供給口109から収納室106内へ不活性ガスを供給することで、この収納室106内を高レベルのクリーン状態とすると共に炉本体102内にも不活性ガスを連続的に流入する。次に、開閉器107によって収納室106と入口部103とを連通し、収納室106内に光ファイバ母材200を炉本体102内に挿入する。そして、この状態で、加熱器105により光ファイバ母材200を軟化溶融してその下端から延伸することで、光ファイバ201が線引きされる。

【0005】なお、このような光ファイバの線引炉は、例えば、特開昭60－155541号公報に開示されている。

【0006】

【発明が解決しようとする課題】上述した従来の光ファイバの線引炉101にあっては、光ファイバ母材200を炉本体102内に挿入する際に、汚染された気体がこの炉本体102内に侵入しないように開閉器107を有する収納室106が設けられている。ところで、近年、光ファイバの量産、低コスト化により光ファイバ母材が大型化されてきている。そのため、大型化された光ファイバ母材から前述した従来の光ファイバの線引炉101を用いて光ファイバ201を線引きする場合には、その光ファイバ母材200の大きさに合わせて収納室106を大きくしなければならず、線引炉101自体が大型化してしまい、設置スペースを大きくとってしまうという問題があった。

【0007】また、光ファイバ201の線引作業中に、光ファイバがガラス構造と伝送特性の規格から外れた場合には線引作業を中止し、線引炉101から光ファイバ母材200を引き上げて取り出し、別の光ファイバ母材を線引炉101内に投入して線引作業を続行する必要がある。このとき、線引炉101から取り出す光ファイバ母材200は2000℃前後に加熱されて輻射熱も増大しており、引き上げ後の光ファイバ母材200のハンドリングが不可能となるためにその安全対策が必須である。

【0008】従って、従来の光ファイバの線引炉101にあっては、加熱された光ファイバ母材200を炉本体102の入口部103や収納室106にて自然冷却を行

う必要があるが、この自然冷却には3時間以上もかかってしまい、光ファイバ母材２００の線引歩留りのアップを考えるとこの光ファイバ母材２００の交換時間を短縮しなければならず、作業性が非常に良くないという問題があった。また、加熱された光ファイバ母材２００を引上げる前に冷却しないと、炉本体１０２の入口部１０３や収納室１０６にて劣化（酸化）が発生し、線引炉１０１内のクリーン度が悪化して線引きされた光ファイバ２０１のガラス強度が著しく低下してしまうという問題があった。

【０００９】本発明はこのような問題点を解決するものであって、装置の省スペース化を図ると共に光ファイバ母材の交換作業の短縮化を図ることができ、且つ、線引きされた光ファイバの強度を高位に保持することのできる光ファイバの線引炉を提供することを目的とする。

【００１０】

【課題を解決するための手段】上述の目的を達成する本発明に係る光ファイバの線引炉は、入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には不活性流体を供給する不活性流体供給を接続したことを特徴とするものである。

【００１１】また、本発明に係る光ファイバの線引炉は、入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には不活性流体を供給する不活性流体供給を接続する一方、前記線引室には炭素及び酸素の濃度変化を検出する濃度計を接続したことを特徴とするものである。

【００１２】また、本発明に係る光ファイバの線引炉は、入口部と出口部とが形成されると共に内部に加熱器が設けられて連続的に流入される不活性ガスで満たされる線引室を有し、該線引室の入口部から挿入される光ファイバ母材を加熱溶融してその出口部から光ファイバを線引きする光ファイバの線引炉において、前記線引室の入口部に連通する光ファイバ母材収納室を該線引室に着脱自在に設けると共に前記線引室と該収納室との間には開閉扉を設け、前記収納室には加熱された前記光ファイバ母材を冷却する冷却装置を装着したことを特徴とするものである。



【００１３】

【作用】光ファイバの線引作業を行うには、まず、内部に光ファイバ母材が収納支持された収納室を線引室の入口部に装着し、線引室に不活性ガスを連続的に流入して充満する一方、収納室には不活性流体供給系により不活性流体を供給する。次に、開閉扉を設けてこの線引室と収納室とを連通し、収納室内の光ファイバ母材を線引室に挿入してこの線引室を密閉状態とする。この状態から加熱器によって光ファイバ母材を加熱溶融し、線引室の出口部から光ファイバを線引きすることで作業を行う。

【００１４】そして、光ファイバの線引作業を行う前、即ち、線引室と収納室とを連通したときにこの線引室内の一酸化炭素（二酸化炭素）及び酸素の濃度変化を濃度計によって検出することで、線引室内を高レベルなクリーン状態に維持できる。

【００１５】また、光ファイバの線引作業中に、特性不良等により光ファイバ母材４１を取出す必要が生じた場合には、線引室内の光ファイバ母材を収納室内に移動し、ここで不活性ガスを供給して加熱した光ファイバ母材４１を強制冷却することにより短時間で交換作業を行うことができる。

【００１６】

【実施例】以下、本発明の実施例を図面に基づいて詳細に説明する。

【００１７】図１には本発明の一実施例に係る光ファイバの線引炉の概略、図２乃至図４には線引炉による光ファイバ線引工程を表す概略を示す。

【００１８】図１に示すように、本実施例の線引炉１１において、円筒形状をなす炉本体１２には入口部１３と出口部１４が形成され、内部にカーボンからなる炉芯管１５が配設されると共にそのカーボン炉芯管１５の外周部にはヒーター１６が装着されている。そして、炉本体１２の入口部１３には開閉自在なシャッター１７が装着される一方、出口部１４には小孔を有する開閉蓋１８が取付けられている。このようにして線引炉１１に線引室Ａが構成される。また、炉本体１２にはこの線引室Ａ内の一酸化炭素（ＣＯ）あるいは二酸化炭素（$CO_2$）の濃度、及び酸素（$O_2$）の濃度変化を検出するＣＯ－$O_2$濃度計１９，２０が接続されている。なお、炉本体１２の周囲は図示しないが水冷構造となっており、また、炉本体１２の上部壁面には図示しない不活性ガス噴出口が円周方向に均一に形成されており、線引室Ａ内に不活性ガスを連続的に流入できるようになっている。

【００１９】この炉本体１２の上部には収納室Ｂを構成する一対の円筒形状をなす枠体２１，２２が着脱自在で、且つ、複数のエアシリンダ２３によって開閉自在に設けられている。この枠体２１，２２において、収納室Ｂと炉本体１２の線引室Ａとは連通可能であり、この連通、遮断動作は前述したシャッター１７によって行われており、また、枠体２１，２２の上部には先端に光ファ

イバ母材４１が保持された支持棒４２が挿通可能な貫通孔２４が形成されている。更に、この支持棒４２には炉本体１２の入口部１３を閉鎖して線引室Ａを気密状態に維持する蓋２５と枠体２１、２２の上部の貫通孔２４を閉鎖して収納室Ｂを気密状態に維持する蓋２６とが取付けられている。

【００２０】また、枠体２１，２２には収納室Ｂ内に不活性ガスとしての窒素（$N_2$）ガスを供給する複数の供給口２７と収納室Ｂ内の一酸化炭素や酸素等を排出する排出口２８が形成されており、供給口２７には$N_2$ガス供給系２９が接続され、排出口２８には図示しない逆止弁が取付けられている。なお、この枠体２１，２２も炉本体１２と同様に周囲が図示しないが水冷構造となっている。

【００２１】而して、かかる線引炉１１を用いて光ファイバ線引作業を行う場合、まず、図１に示すように、シャッター１７を閉じて線引室Ａを密閉状態に遮断し、炉本体１２内のガス噴出口から線引室Ａ内に窒素ガスを連続的に流入する。一方、支持棒４２に保持された光ファイバ母材４１を下降すると共に各エアシリンダ２３を作動して一対の枠体２１，２２を接近させて密着することで、図２に示すように、この枠体２１，２２により収納室Ｂ内に光ファイバ母材４１を収納する。そして、ガス供給系２９により各供給口２７からこの収納室Ｂ内へ窒素ガスを供給して充満させる一方、排出口２８から不要の一酸化炭素や酸素を排出し、収納室Ｂ内を高レベルのクリーン状態とする。

【００２２】この状態からシャッター１７を開けて線引室Ａと収納室Ｂとを連通し、光ファイバ母材４１を下降して線引室Ａ内に挿入すると、図３に示すように、この光ファイバ母材４１はこの線引室Ａの所定の位置に保持され、且つ、炉本体１２の入口部１３は蓋２６によって閉鎖され、線引室Ａは密閉状態となる。このとき、２つの$CO-O_2$濃度計１９，２０によって線引室Ａ内の一酸化炭素（二酸化炭素）及び酸素の濃度変化を測定し、線引室Ａと収納室Ｂとの連通時に不要なガス等が侵入したかどうかを検出する。即ち、光ファイバ母材４１は炉本体１２内でヒーター１６により２０００度以上に加熱されており、このときに炉芯管１５内には種々のガスやダスト等が発生し、光ファイバ母材４１の表面に付着して光ファイバ４３の表面に損傷を与え、その強度を著しく低下させてしまうことがある。そのため、この濃度計１９，２０により濃度変化が検出されたなら、即ち、一酸化炭素（二酸化炭素）や酸素が侵入して濃度が高くなっていれば、炉本体１２内のガス噴出口から線引室Ａ内への窒素ガスの流量を制御して高レベルのクリーン状態を維持する。

【００２３】そして、この状態でヒーター１６により光ファイバ母材４１を軟化溶融してその下端から延伸することで、光ファイバ４３の線引作業を行う。



【００２４】ところで、光ファイバ４３の線引作業においても$CO-O_2$濃度計１９，２０によって線引室Ａ内の一酸化炭素（二酸化炭素）及び酸素の濃度変化を検出し、常時、オンラインで管理している。即ち、前述したように、線引室Ａ内に窒素ガスを連続して流入しても一酸化炭素及び酸素を完全に除去することはできず、若干の一酸化炭素及び酸素が残存してしまう。光ファイバ４３の線引作業中、炉本体１２（線引室Ａ）内における温度変化に対する線引室Ａ内に残存している一酸化炭素と酸素の濃度変化の割合を調べてみる。すると、線引室Ａ内が５００度程度では酸素濃度が高く、一酸化炭素濃度は非常に低くなっているが、線引室Ａ内を加熱して温度を上昇させていくと、酸素濃度は低下していく一方一酸化炭素濃度は上昇し、線引室Ａ内が２０００度以上になると、酸素濃度が低く、一酸化炭素濃度は非常に高くなっている。

【００２５】光ファイバ４３の線引作業中に炉本体１２（線引室Ａ）が高温に加熱されると、炉芯管１５がカーボン（炭素）であるために下記に示す反応が起こる。

【化１】$2O_2 + 3C \rightarrow 2CO + CO_2$

【００２６】即ち、線引室Ａに残存している酸素（$O_2$）に炉芯管１５の炭素（Ｃ）が反応し、一酸化炭素（ＣＯ）あるいは二酸化炭素（$CO_2$）が発生する。従って、線引室Ａの温度上昇によって酸素濃度が低下していく一方、一酸化炭素濃度は上昇していく。本実施例では、光ファイバ４３の線引作業中におけるこの一酸化炭素及び酸素の濃度変化を$CO-O_2$濃度計１９，２０によって検出することでこの線引室Ａ内を高レベルのクリーン状態に維持するようにしている。具体的には、線引室Ａの温度上昇に伴って$CO-O_2$濃度計１９，２０によって酸素濃度及び一酸化炭素濃度を測定し、酸素濃度の低下及び一酸化炭素濃度の上昇を検出したら線引室Ａ内に不活性ガスとしての窒素を連続して流入し、増加した一酸化炭素を排出するようにする。

【００２７】ところで、光ファイバ４３の線引作業中に、光ファイバ４３がガラス構造と伝送特性の規格から外れた場合には線引作業を中止し、線引炉１１から光ファイバ母材４１を引き上げて取り出し、別の光ファイバ母材を線引炉１１内に投入して線引作業を続行する必要がある。この場合、前述とは逆に、線引室Ａ内の光ファイバ母材４１を引き上げて、図２に示すように、枠体２１，２２の収納室Ｂ内に戻してシャッター１７を閉じる。そして、図４に示すように、枠体２１，２２を内部に収納した光ファイバ母材４１と共に上方に移動し、この枠体２１，２２の下部を開放する。この状態でガス供給系２９により各供給口２７から収納室Ｂ内へ窒素ガスを供給し、加熱した光ファイバ母材４１を強制冷却する。すると、ほぼ２０～３０分程度で冷却することができる。そして、各エアシリンダ２３を作動して一対の枠体２１，２２を離反させて開放し、常温に冷却された光

ファイバ母材４１を引き上げて取り出す。

【００２８】このように本実施例の光ファイバの線引炉１１にあっては、光ファイバ母材４１を収納する枠体２１，２２を２分割としてエアシリンダ２３によって開閉自在に設けたことで、大型の光ファイバ母材４１であっても十分に収納することができ、収納室Ｂ（枠体２１，２２）を大型化する必要がなくなって省スペース化が図れる。また、光ファイバ４３の線引作業前及び作業中において、ＣＯ－$O_2$ 濃度計１９，２０によって線引室Ａ内の一酸化炭素（二酸化炭素）及び酸素の濃度変化を検出しているので、線引室Ａ内を常時高レベルなクリーン状態に維持できる。更に、光ファイバ母材４１の取出作業時には、線引室Ａ内の光ファイバ母材４１を枠体２１，２２の収納室Ｂ内に収納し、ここでガス供給系２９により窒素ガスを供給して加熱した光ファイバ母材４１を強制冷却することができ、短時間で作業を行うことができる。

【００２９】図５には本発明の別の実施例に係る光ファイバの線引炉の概略、図６乃至図８には線引炉による光ファイバ線引工程を表す概略を示す。なお、前述した実施例と同様の機能を有する部材には同一の符号を付して重複する説明は省略する。

【００３０】図５に示すように、本実施例の線引炉５１において、円筒形状をなす炉本体１２には入口部１３と出口部１４が形成され、内部に炉芯管１５及びヒーター１６が配設されている。そして、炉本体１２の入口部１３にはシャッター１７が、出口部１４には開閉蓋１８が取付けられると共に炉本体１２にはＣＯ－$O_2$ 濃度計１９，２０が接続されて線引室Ａが構成されている。この炉本体１２の上部には収納室Ｂを構成する円筒形状をなす枠体５２が図示しない複数のエアシリンダによって炉本体１２の入口部１３に対して摺動自在で、且つ、着脱自在に設けられている。この枠体５２において、収納室Ｂと線引室Ａとは連通しており、シャッター１７によって遮断できるようになっている。また、この枠体５２の上部には連結部５３により先端に光ファイバ母材４１が保持された支持棒４２が連結されている。更に、枠体５２には複数の供給口２７と排出口２８が形成されており、供給口２７には$N_2$ ガス供給系２９が接続されている。

【００３１】而して、かかる線引炉１１を用いて光ファイバ線引作業を行う場合、まず、図５に示すように、シャッター１７を閉じて線引室Ａを密閉状態に遮断し、炉本体１２内のガス噴出口から線引室Ａ内に窒素ガスを連続的に流入する。一方、支持棒４２に保持された光ファイバ母材４１を枠体５２と共に下降し、図６に示すように、枠体５２の下部をこの枠体５２の入口部１３に連結する。そして、ガス供給系２９により各供給口２７からこの収納室Ｂ内へ窒素ガスを供給して充満させる一方、排出口２８から不要の一酸化炭素や酸素を排出し、収納室Ｂ内を高レベルのクリーン状態とする。

【００３２】この状態からシャッター１７を開けて線引室Ａと収納室Ｂとを連通し、光ファイバ母材４１を下降して線引室Ａ内に挿入すると、図７に示すように、この光ファイバ母材４１はこの線引室Ａの所定の位置に保持される。このとき、２つのＣＯ－$O_2$ 濃度計１９，２０によって線引室Ａ内の一酸化炭素（二酸化炭素）及び酸素の濃度変化を測定し、線引室Ａと収納室Ｂとの連通時に不要なガス等が侵入したかどうかを検出し、線引室Ａ内への窒素ガスの流量を制御して高レベルのクリーン状態を維持する。そして、この状態でヒーター１６により光ファイバ母材４１を軟化溶融してその下端から延伸することで、光ファイバ４３の線引作業を行う。

【００３３】光ファイバ４３の線引作業中に光ファイバ４３に特性不良が発生した場合には、線引室Ａ内の光ファイバ母材４１を引き上げて、図６に示すように、枠体５２の収納室Ｂ内に戻してシャッター１７を閉じる。そして、図８に示すように、枠体５２を内部に収納した光ファイバ母材４１と共に上方に移動し、この枠体５２の下部を開放する。この状態でガス供給系２９により各供給口２７から収納室Ｂ内へ窒素ガスを供給し、加熱した光ファイバ母材４１を強制冷却する。そして、光ファイバ母材４１が常温まで冷却されると、枠体５２から取り外して収納室Ｂから取り出す。

【００３４】このように本実施例の光ファイバの線引炉５１にあっては、光ファイバ母材４１を収納する枠体５２をエアシリンダによって炉本体１２の入口部１３に対して摺動自在で、且つ、着脱自在に設けたことで、大型の光ファイバ母材４１であっても十分に収納することができ、線引作業時には枠体５２を炉本体１２に対して摺動嵌合することで短縮することができ、省スペース化が図れる。

【００３５】

【発明の効果】以上、実施例を挙げて詳細に説明したように、本発明の光ファイバの線引炉によれば、光ファイバの線引室の入口部に連通する光ファイバ母材収納室をその線引室に対して着脱自在に設けると共に線引室と収納室との間に開閉扉を設けて収納室に不活性流体を供給する不活性流体供給系を接続したので、大型の光ファイバ母材であっても十分に収納することができ、収納室を大型化する必要がなくなって省スペース化を図ることができ、作業スペースを確保することができると共に作業性を向上することができる。

【００３６】また、線引室に炭素及び酸素の濃度変化を検出する濃度計を接続したので、光ファイバの線引作業前に濃度計によって線引室内の炭素及び酸素の濃度変化を検出することで線引室内を常時高レベルなクリーン状態に維持することができ、線径変動のない光ファイバを連続的に製造することができる。

【００３７】更に、収納室に加熱された光ファイバ母材

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を冷却するための冷却装置を装着したので、光ファイバ母材の取出作業時に線引室内の光ファイバ母材を収納室内に収納した状態で不活性ガスを供給して加熱した光ファイバ母材を強制冷却することができ、安全性を向上することができると共に作業人名を短縮することができる。

【図面の簡単な説明】

【図1】本発明の一実施例に係る光ファイバの線引炉の概略図である。

【図2】線引炉による光ファイバ線引工程を表す概略図である。

【図3】線引炉による光ファイバ線引工程を表す概略図である。

【図4】線引炉による光ファイバ線引工程を表す概略図である。

【図5】本発明の別の実施例に係る光ファイバの線引炉の概略図である。

【図6】線引炉による光ファイバ線引工程を表す概略図である。

【図7】線引炉による光ファイバ線引工程を表す概略図である。

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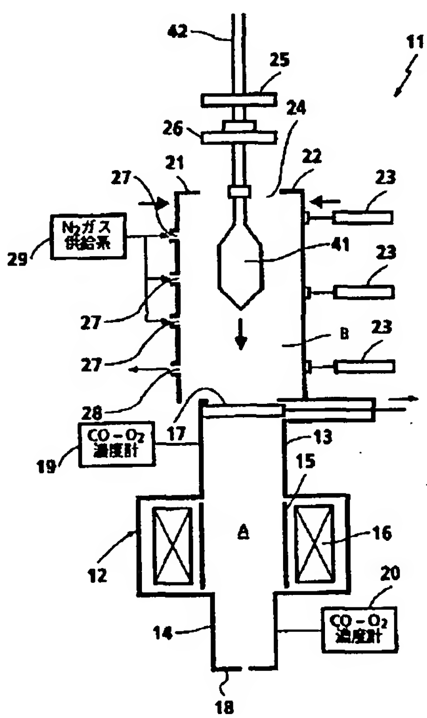
【図8】線引炉による光ファイバ線引工程を表す概略図である。

【図9】従来の光ファイバの線引炉を表す概略図である。

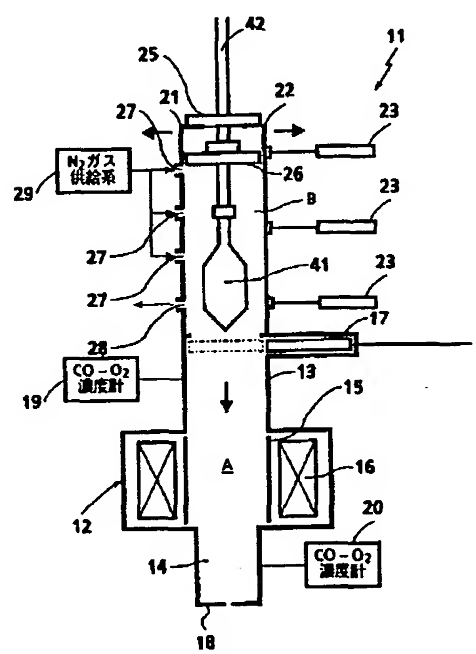
【符号の説明】

11，51 線引炉
12 炉本体
13 入口部
14 出口部
15 炉芯管
16 ヒーター
17 シャッター
19，20 $CO-O_2$ 濃度計
21，22，52 枠体
27 供給口
28 排出口
29 窒素ガス供給系
41 光ファイバ母材
43 光ファイバ
A 線引室
B 収納室

【図1】

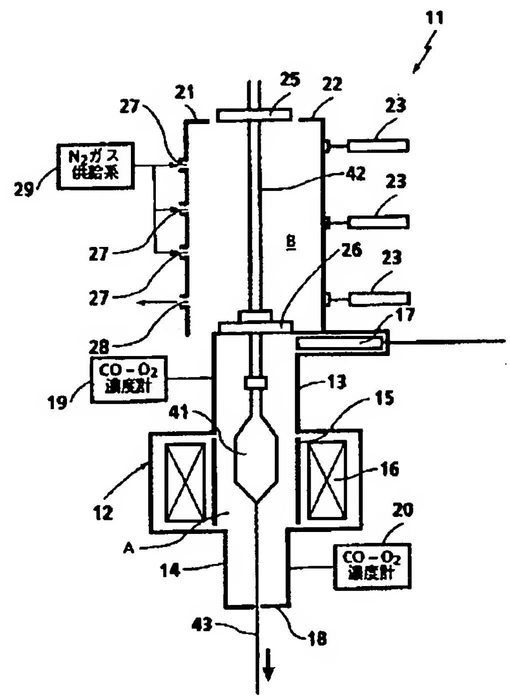



【図2】

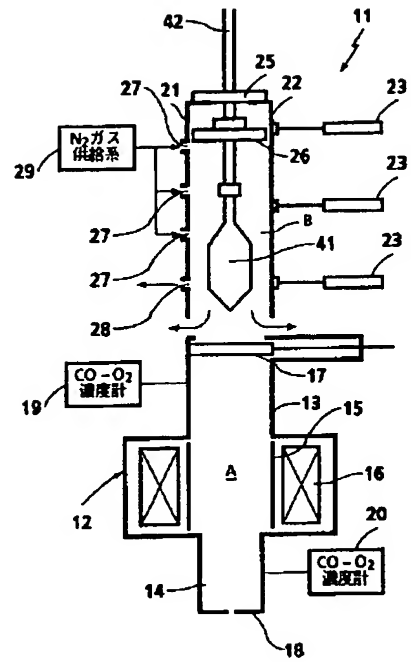



WEST

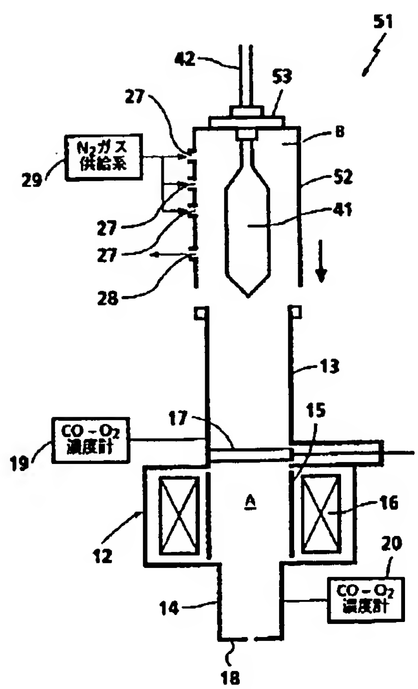
【図3】


N2ガス供給系
CO－O2濃度計
CO－O2濃度計

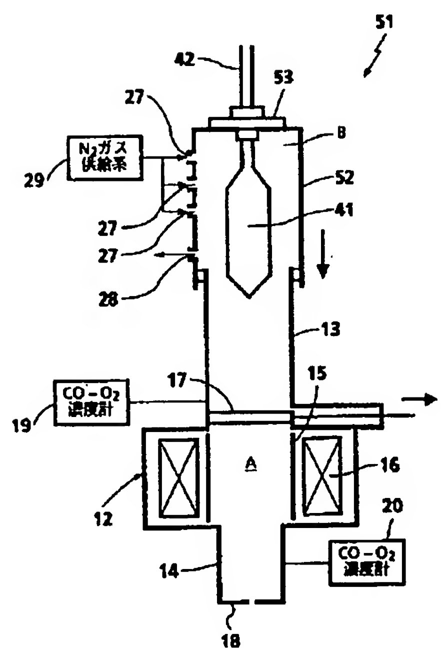
【図4】


N2ガス供給系
CO－O2濃度計
CO－O2濃度計

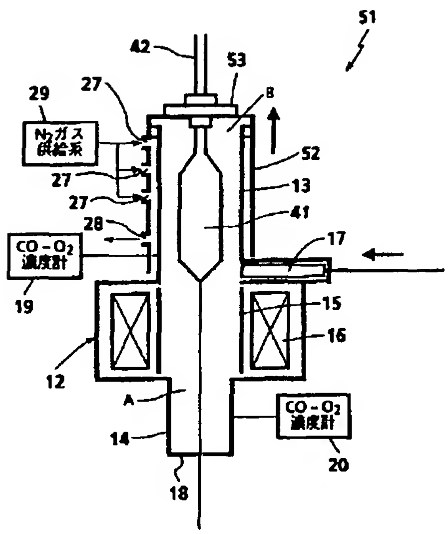
【図5】


N2ガス供給系
CO－O2濃度計
CO－O2濃度計

【図6】


N2ガス供給系
CO－O2濃度計
CO－O2濃度計

【図7】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N2ガス供給系
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CO－O2濃度計
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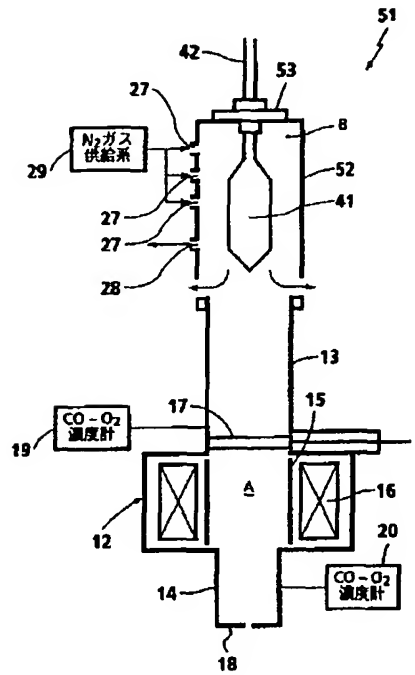
【図8】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N2ガス供給系
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CO－O2濃度計
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CO－O2濃度計
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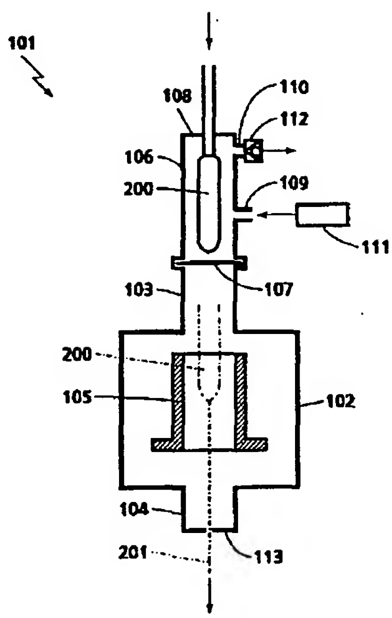
【図9】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PTO 99-3921 Japanese Kokai Patent Application No. Hei 6[1994]B199536

# OPTICAL FIBER DRAWING FURNACE

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JAPANESE PATENT OFFICE
PATENT JOURNAL
KOKAI PATENT APPLICATION NO. HEI 6[1994]-199536

Technical Disclosure Section

| | |
|---|---|
| Int. Cl. $^{5}$: | C 0 3 B 37/027<br>G 0 2 B 6/00 |
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# OPTICAL FIBER DRAWING FURNACE
[Hikari-faiba no senbiki-ro]

| | |
|---|---|
| Inventors: | Kohei Kobayashi and<br>Kaoru Okuno |
| Applicant: | Sumitomo Electric<br>Industries Ltd. |

[There are no amendments to this patent.]

Claims /2*

1. Optical fiber drawing furnace characterized in that in an optical fiber drawing furnace provided with a drawing chamber having an entrance and an exit as well as an internal heater and which is filled with a continuously introduced inert gas by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, and an inert gas supply system to supply inert gas is connected to the aforementioned housing chamber.

2. Optical fiber drawing furnace characterized in that in an optical fiber drawing furnace provided with a drawing chamber having an entrance and an exit as well as an internal heater and which is filled with continuously introduced inert gas by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, an inert gas supply system to supply inert gas is connected to the aforementioned housing chamber, and densitometers for the detection of changes in the densities of carbon and oxygen are connected to the aforementioned drawing chamber.

3. Optical fiber drawing furnace characterized in that in an optical fiber drawing furnace

* [Numbers in margin indicate pagination in the foreign text.]

provided with a drawing chamber having an entrance and an exit as well as an internal heater and which is filled with a continuously introduced inert gas by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, and a cooling device for cooling the aforementioned optical fiber preform is installed the aforementioned housing chamber.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to an optical fiber drawing furnace capable of producing an optical fiber with little variation in fiber diameter from a large optical fiber preform.

[0002]

Prior art

Conventionally, optical fiber drawing furnaces have been utilized in order to obtain an optical fiber by heat-melting and drawing an optical fiber preform (will also be simply referred to as a preform hereinafter). Figure 9 shows a simplified diagram of a conventional optical fiber drawing furnace.

[0003]

As shown in Figure 9, in a drawing furnace (101), an entrance (103) and an exit (104) are formed in the furnace main body (102), and a heater (105) is installed therein. A housing chamber (106) is provided at the top of said furnace main body (102), and an opening/closing device (107) which can be closed off is placed between said housing chamber (106) and the entrance (103) of the furnace main body (102). An opening/closing lid (108) for inserting an optical fiber preform (200) is attached to the top of the housing chamber (106), a supply opening (109) and an exhaust opening (110) are formed for supplying/exhausting a gas, a gas supply system (111) is connected to the supply opening (109) in order to supply an inert gas in said housing chamber (106), and a backflow prevention valve (112) is attached to the exhaust opening (110). In addition, an opening/closing lid (113) with a small hole through which an optical fiber (201) can be drawn is attached to the exit (104) of the furnace main body (102).

[0004]

To carry out the optical fiber drawing operation using such drawing furnace (101), first, the connection between the housing chamber (106) and the entrance (103) is shut off by means of the opening/closing device (107), the optical fiber preform (200) is inserted into said housing chamber (106), and the opening/closing lid (108) is closed to create an airtight condition. Then, a highly clean condition is created in said housing chamber (106) by supplying an inert gas from the supply opening (109) to the housing chamber (106) by means of the gas supply system (111), and the inert gas is continuously introduced into the furnace main body (102). Next, the housing chamber (106) and the entrance (103) are linked by means of the opening/closing device (107),

and the optical fiber preform (200) in the housing chamber (106) is inserted into the furnace main body (102). Then, under this condition, the optical fiber preform (200) is softened by means of the heater (105) and drawn from the bottom in order to draw an optical fiber (201).

[0005]

Incidentally, this type of optical fiber drawing furnace is disclosed, for example, in Japanese Kokai Patent Application No. Sho 60 [1985]-15554.

[0006]

Problems to be solved by the invention

In the case of the conventional optical fiber drawing furnace (101) described above, the housing chamber (106) having the opening/closing device (107) is provided in order to prevent contaminated air from invading the furnace main body (102) when the optical fiber preform (200) is inserted into the furnace main body (102). Incidentally, in recent years, optical fiber preforms have become larger due to mass-production technique and the low cost of optical fibers. Thus, when drawing an optical fiber (201) from a larger optical fiber preform using the aforementioned conventional optical fiber drawing furnace (101), the housing chamber (106) must be made larger to accommodate the size of said optical fiber preform (200). As a result, there was the problem that the drawing furnace (101) itself became large and took up a large amount of floor space.

[0007]

In addition, when the optical fiber falls short of the standards in terms of glass structures and transmission characteristics during the drawing operation of the optical fiber (201), the drawing operation must be stopped, the optical fiber preform (200) must be removed from the drawing furnace (101), and a different optical fiber preform must be placed in the drawing furnace (101) in order to continue the drawing operation. In such a case, because the optical fiber preform (200) removed from the drawing furnace (101) is heated to around 2,000EC with increased radiant heat, making it impossible to handle the removed optical fiber preform (200), safety measures in this regard must be taken.

[0008]

Therefore, in the conventional optical fiber drawing furnace (101), it was required to let the heated optical fiber preform (200) cool off naturally at the entrance (103) of the furnace main body (102) and in the housing chamber (106). However, this natural cooling took 3 h or longer, resulting in the problem of poor efficiency because the time used for the replacement of/3 said optical fiber preform (200) had to be reduced in consideration of increase in the drawing yield of the optical fiber preform (200). In addition, there was the problem that if the heated optical fiber preform (200) was not cooled before it was pulled up, deterioration (oxidization) occurred at the entrance (103) of the furnace main body (102) and in the housing chamber (106), and the cleanliness of the drawing furnace (101) was compromised, resulting in a significant drop in the glass strength of the optical fiber (201) drawn.

[0009]

The purpose of the present invention is to solve these problems, and offers a drawing furnace for an optical fiber capable of saving device floor space, reducing the time for the optical fiber preform replacement operation, and maintaining the strength of the optical fiber drawn at a high level.

[0010]

Means to solve the problems

In order to solve the aforementioned problems, the optical fiber drawing furnace of the present invention is characterized in that in an optical fiber drawing furnace provided with a drawing chamber having an entrance and an exit as well as an internal heater and which is filled with a continuously introduced inert gas, by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, and an inert gas supply system to supply inert gas is connected to the aforementioned housing chamber.

[0011]

In addition, the optical fiber drawing furnace pertaining to the present invention is characterized in that in an optical fiber drawing furnace provided with a drawing chamber having

an entrance and an exit as well as an internal heater and filled with a continuously introduced inert gas, by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, an inert gas supply system to supply inert gas is connected to the aforementioned housing chamber, and densitometers for the detection of changes in the densities of carbon and oxygen are connected to the aforementioned drawing chamber.

[0012]

In addition, the optical fiber drawing furnace pertaining to the present invention is characterized in that in an optical fiber drawing furnace provided with a drawing chamber having an entrance and an exit as well as an internal heater and filled with a continuously introduced inert gas, by which an optical fiber preform to be inserted from the entrance of said drawing chamber is heat-melted in order to draw an optical fiber from the exit, an optical fiber preform housing chamber to be connected to the entrance of the aforementioned drawing chamber is provided in such a way that it can be attached to or detached from said drawing chamber, a door is provided between the aforementioned drawing chamber and said housing chamber, and a cooling device for cooling the aforementioned optical fiber preform is installed the aforementioned housing chamber.

[0013]

Function

To carry out the optical fiber drawing operation, first, the housing chamber, in which an optical fiber preform is housed and supported, is attached to the entrance of the drawing chamber, and an inert gas is continuously introduced into the drawing chamber, while an inert gas is supplied to the housing chamber through the inert gas supplying system. Then, the door provided for connecting said drawing chamber to the housing chamber is opened, the optical fiber preform in the housing chamber is inserted into the drawing chamber, and an airtight condition is created in said drawing chamber. Under this condition, the optical fiber preform is heat-melted by means of the heater, and the optical fiber is drawn from the exit of the drawing chamber to complete the operation.

[0014]

In addition, a highly clean condition can be maintained inside the drawing chamber by detecting the changes in the densities of carbon monoxide (carbon dioxide) and oxygen in said drawing chamber prior to the optical fiber drawing operation, that is, when the drawing chamber and the housing chamber are connected.

[0015]

Also, if a need arises to remove the optical fiber preform (41) due to poor characteristics during the optical fiber drawing operation, the optical fiber preform in the drawing chamber is transferred into the housing chamber, and the inert gas is supplied thereto in order to cool the

heated optical fiber preform (41) forcibly, so that the replacement operation can be completed in a short period of time.

[0016]

Application examples

Details of application examples of the present invention will be explained below with reference to the figures.

[0017]

A diagram of the optical fiber drawing furnace pertaining to an application example of the present invention is shown in Figure 1; and a diagram of the optical fiber drawing processes using the drawing furnace is shown in Figures 2 through 4.

[0018]

As shown in Figure 1, in the drawing furnace (11) of the present application example, an entrance (13) and an exit (14) are formed in a cylindrical furnace main body (12), a core pipe (15) made of carbon is provided inside, and a heater (16) is attached to the periphery of said carbon core pipe (15). Then, a shutter (17) which can be opened/closed freely is attached to the entrance (13) of the furnace main body (12), and an opening/closing lid (18) with a small hole is attached to the exit (14). A drawing chamber (A) is formed in the drawing furnace (11) in this manner. In addition, $CO$-$O_2$ densitometers (19) and (20) are connected to the furnace main body (12) in order to detect the density of carbon monoxide ($CO$) or carbon dioxide ($CO_2$) and the

density of oxygen ($O_2$) in said drawing chamber (A). Furthermore, the periphery of the furnace main body (12) is made into a water-cooled structure (not shown in the figure). In addition, an inert gas injection port not shown in the figure is formed uniformly at the upper wall surface of the furnace main body (12) in the direction of its circumference; the inert gas can thus be continuously introduced into the drawing chamber (A).

[0019]

A pair of frame bodies (21) and (22) to be combined into a cylindrical shape to constitute a housing chamber (B) are provided at the top of said furnace main body (12) in such a way that the housing chamber can be attached/detached freely and can be opened/closed freely by means of several air cylinder units (23). The housing chamber (B) and the drawing chamber (A) of the furnace main body (12) can be connected to each other at said frame bodies (21) and (22); said linking and the shut-off operations are carried out by the shutter (17) described above; and a through-hole (24) for putting through a bearing bar (42) holding the optical fiber preform (41) by the end is created at the top of the frame bodies (21) and (22). Furthermore, a lid (25) /4 for closing up the entrance (13) of the furnace main body (12) in order to maintain an airtight condition in the drawing chamber (A) and a lid (26) for closing up the through-hole (24) at the top of the frame bodies (21) and (22) in order to keep an airtight condition in the housing chamber (B) are attached to said bearing bar (42).

[0020]

In addition, several supply ports (27) for supplying nitrogen ($N_2$) gas as the inert gas into the housing chamber (B) and an exhaust opening (28) for exhausting the carbon monoxide and the oxygen from the housing chamber (B) are formed on the frame bodies (21) and (22), an $N_2$ gas supply system is connected to the supply openings (27), and a backflow prevention valve (not shown in the figure) is attached to the exhaust opening (28). Furthermore, although not shown in the figure, the periphery of said frame bodies (21) and (22) is also made into a water-cooled structure just like the furnace main body (12).

[0021]

When carrying out the optical fiber drawing operation using such drawing furnace (11), as shown in Figure 1, first, the shutter (17) is closed to create an airtight condition in the drawing chamber (A), and the nitrogen gas is continuously introduced into the drawing chamber (A) from a gas injection opening in the furnace main body (12). On the other hand, the optical fiber preform (41) held by the bearing bar (42) is lowered, and the respective air cylinders (23) are operated to bring the pair of frame bodies (21) and (22) closer until they are put together tightly in order to house the optical fiber preform (41) in the housing chamber (B) by means of said frame bodies (21) and (22), as shown in Figure 2. Then, the nitrogen gas is supplied into said housing chamber (B) from the respective supply openings (27) by means of the gas supply system (29) until it is filled, and unnecessary carbon monoxide and oxygen are exhausted from the exhaust opening (28) in the meanwhile in order to create a highly clean condition in the housing chamber (B).

[0022]

In this condition, when the shutter (17) is opened to connect the drawing chamber (A) to the housing chamber (B), and the optical fiber preform (41) is lowered and inserted into the drawing chamber (A), as shown in Figure 3, said optical fiber preform (41) is held to a specific position in said drawing chamber (A), and the entrance (13) of the furnace main body (12) is closed off by the lid (26) to create an airtight condition in the drawing chamber (A). At this time, changes in the densities of carbon monoxide (carbon dioxide) and oxygen in the drawing chamber (A) are measured using the 2 $COBO_2$ densitometers (19) and (20) in order to detect whether unnecessary gas was introduced when the drawing chamber (A) and the housing chamber (B) were connected. The optical fiber preform (41) is heated to 2,000EC or higher in the furnace main body (12) by the heater (16), and various types of gases and dust are formed in the carbon core pipe (15). Sometimes, they adhere to the surface of the optical fiber preform (41), and the surface of the optical fiber (43) becomes damaged, deteriorating its strength significantly. Thus, when a change in density is detected by said densitometers (19) and (20), that is, when there has been an increase in density by the invasion by carbon monoxide (carbon dioxide) and oxygen, the flow rate of the nitrogen gas from the gas injection opening in the furnace main body (12) into the drawing chamber (A) is controlled to maintain the highly clean condition.

[0023]

Then, under said condition, the optical fiber preform (41) is soft-melted by the heater (16) and drawn from the bottom during the drawing operation for the optical fiber (43).

[0024]

Incidentally, changes in the densities of carbon monoxide (carbon dioxide) and oxygen in the drawing chamber (A) are measured using the two COB$O_2$ densitometers (19) and (20) for constant on-line management also during the drawing operation for the optical fiber (43). That is, as described above, even when the nitrogen gas is introduced continuously into the drawing chamber (A), carbon monoxide sand oxygen cannot be completely removed, leaving a slight amount of carbon monoxide and oxygen therein. The ratio of the changes in the densities of the carbon monoxide and oxygen remaining in the drawing chamber (A) relative to the changes in the temperature in the furnace main body (12) (drawing chamber (A)) during the drawing operation for the optical fiber (43) is examined. Then, it is found that although the density of oxygen is high, and the density of carbon monoxide is extremely low when inside the drawing chamber (A) is around 500EC, as the temperature rises when the drawing chamber (A) is heated, the density of oxygen keeps dropping, and the density of carbon monoxide increases. When inside the drawing chamber (A) reaches 2,000EC and higher, the density of oxygen is low, and the density of carbon monoxide is extremely high.

[0025]

If the furnace main body (12) (drawing chamber (A)) is heated to a high temperature during the drawing operation for the optical fiber (43), the following reactions occur due to the fact that the core pipe (15) is made of carbon.

Equation 1: $2O_2 + 3C$ 6 $2CO + CO_2$

[0026]

That is, the carbon (C) of the core pipe (15) reacts with the oxygen ($O_2$) remaining in the drawing chamber (A) to generate carbon monoxide (CO) or carbon dioxide ($CO_2$). Therefore, as the temperature in the drawing chamber (A) increases, the density of oxygen keeps dropping and the density of carbon monoxide keeps increasing. In the present application example, the highly clean condition is maintained in the drawing chamber (A) by detecting said changes in the densities of carbon monoxide and oxygen during the drawing operation of the optical fiber (43) using the $COBO_2$ densitometers (19) and (20). More specifically, the density of oxygen and density of carbon monoxide are measured using the $COBO_2$ densitometers (19) and (20) as the temperature in the drawing chamber (A) increases; with the detection of a drop in the density of oxygen and an increase in the density of carbon monoxide, nitrogen as an inert gas is continuously introduced into the drawing chamber (A) in order to exhaust the increased carbon monoxide.

[0027]

Incidentally, if the optical fiber (43) falls short of the standards pertaining to glass structures and transmission characteristics during the drawing operation of the optical fiber (43), the drawing operation must be suspended, the optical fiber preform (41) is pulled out of the drawing furnace (11), and a different optical fiber preform is input into the drawing furnace (11) in order to continue the drawing operation. In such a case, contrary to the aforementioned case, the optical fiber preform (41) in the drawing chamber (A) is pulled out and returned to the housing chamber (B) made of the frame bodies (21) and (22), and the shutter (17) is closed as

shown in Figure 2. Then, as shown in Figure 4, the frame bodies (21) and (22) are moved upward along with the optical fiber preform (41) contained therein, and the bottom of said frame bodies (21) and (22) are opened. Under this condition, nitrogen gas is supplied through the respective supply openings (27) into the housing chamber (B) by means of the gas supply system (29) in order to cool the heated optical fiber preform (41) forcibly. Then, it can be cooled in about 20-30 min. Then, the respective air cylinders (23) are actuated to open the pair of frame bodies (21) and (22), and the optical fiber preform (41) already cooled to the normal temperature is removed.

[0028]

As described above, in the optical fiber drawing furnace (11) of the present application example, because the frame bodies (21) and (22) for housing the optical fiber preform (41) are provided as 2 split pieces to allow them to be opened/closed freely by means of the air cylinders (23), even a large optical fiber preform (41) can be easily accommodated, so that the housing chamber (B) (frame bodies (21) and (22)) need not be made larger, and the space can be saved. In addition, because the $COBO_2$ densitometers (19) and (20) are used to detect the densities of the carbon monoxide (carbon dioxide) and the oxygen in the drawing chamber (A) before and during the drawing operation for the optical fiber (43), inside the drawing chamber (A) can be maintained in a highly clean condition constantly. Furthermore, during the operation for removing the optical fiber preform (41), the optical fiber preform (41) in the drawing chamber (A) is housed into the housing chamber (B) made of the frame bodies (21) and (22), and the nitrogen gas is supplied by the gas supply system (29) to cool the heated optical fiber preform

(41) forcibly, so that the operation can be completed in a short period of time.

[0029]

A diagram of the optical fiber drawing furnace pertaining to another application example of the present invention is shown in Figure 5, and a diagram of the optical fiber drawing process using the drawing furnace is shown in Figures 6 through 8. The elements having the same functions as those in the aforementioned application example are assigned the same reference numbers, and their explanation is omitted.

[0030]

As shown in Figure 5, in the drawing furnace (51) of the present application example, an entrance (13) and an exit (14) are formed in a cylindrical furnace main body (12), and a core pipe (15) and a heater (16) are provided. Then, a shutter (17) is attached to the entrance (13) of the furnace main body (12), an opening/closing lid (18) with a small hole is attached to the exit (14), and CO-$O_2$ densitometers (19) and (20) are connected to the furnace main body (12) in order to form a drawing chamber (A). A cylindrical frame body (52) constituting a housing chamber (B) is provided at the top of said furnace main body (12) in such a way that it can slide freely relative to the entrance (13) of the furnace main body (12) and freely be attached/detached. In said frame body (52), the drawing chamber (A) and the housing chamber (B) are connected and can be shut off from each other by the shutter (17). In addition, a bearing bar (42) holding an optical fiber preform (41) by the end by means of a linkage part (53) is linked to the top of said frame body (52). Several supply openings (27) and an exhaust opening (28) are formed in the frame body

(52), and an $N_2$ gas supply system (29) is connected to the supply openings (27).

[0031]

When carrying out the optical fiber drawing operation using such drawing furnace (11), as shown in Figure 5, first, the shutter (17) is closed to create an airtight condition in the drawing chamber (A), and the nitrogen gas is introduced continuously into the drawing chamber (A) from a gas injection opening in the furnace main body (12). On the other hand, the optical fiber preform (41) held by the bearing bar (42) is lowered along with the frame body (52) in order to link the bottom of the frame body (52) to the entrance (13) of said frame body (52) as shown in Figure 6. Then, the nitrogen gas is supplied into said housing chamber (B) from the respective supply openings (27) by means of the gas supply system (29) until it is filled, and unnecessary carbon monoxide and oxygen are exhausted from the exhaust opening (28) in order to create a highly clean condition in the housing chamber (B).

[0032]

From this condition, when the shutter (17) is opened to link the drawing chamber (A) to the housing chamber (B), and the optical fiber preform (41) is lowered and inserted into the drawing chamber (A), as shown in Figure 7, said optical fiber preform (41) is held to a specific position in said drawing chamber (A). At this time, changes in the densities of carbon monoxide (carbon dioxide) and oxygen in the drawing chamber (A) are measured using the two $COBO_2$

densitometers (19) and (20) in order to detect whether unnecessary gas was introduced when the drawing chamber (A) and the housing chamber (B) were connected, and the flow rate of the nitrogen the drawing chamber (A) is controlled in order to maintain the highly clean condition. Then, under said condition, the optical fiber preform (41) is soft-melted by the heater (16) and drawn from the bottom during the drawing operation for the optical fiber (43).

[0033]

If a poor characteristic of the optical fiber (43) occurs during the drawing operation for the optical fiber (43), as shown in Figure 6, the optical fiber preform (41) is removed from the drawing chamber (A) and returned to the housing chamber (B) of the frame body (52), and the shutter (17) is closed. Then, as shown in Figure 8, the frame body (52) is moved upward along with the optical fiber preform (41) contained therein , and the bottom of said frame body (52) is opened. Under this condition, nitrogen gas is supplied through the respective supply ports (27) into the housing chamber (B) by means of the gas supply system (29) in order to cool the heated optical fiber preform (41) forcibly. Then, when cooled down to the normal temperature, the optical fiber preform (41) is removed from the frame body (52) and the housing chamber (B).

[0034]

As described above, in the optical fiber drawing furnace (51) of the present application example, because the frame body (52) housing the optical fiber preform (41) is provided in such a way that it can slide freely relative to the entrance (13) of the furnace main body (12) by means of the air cylinders and be freely attached/detached, even a large optical fiber preform (41) can be

easily accommodated, the frame body (52) can be shortened by sliding it to fit the furnace main body (12) during the drawing operation, so the space can be saved.

[0035]

Effects of the invention

As described above in detail using application examples, in the optical fiber drawing furnace of the present invention, because the optical fiber preform housing chamber connected to the entrance of the optical fiber drawing chamber is provided in such a way that it can be freely attached to or detached from said drawing chamber, a door is provided between the drawing chamber and the housing chamber, and the inert gas supply system for supplying an inert gas is connected to the housing chamber, even a large optical fiber preform can be housed sufficiently. Thus, there is no need to make the housing chamber larger, space can be saved, and the efficiency of the operation improved.

[0036]

In addition, because densitometers for detecting changes in the densities of carbon and oxygen are connected to the drawing chamber, a highly clean condition can be maintained in the drawing chamber by detecting changes in the densities of carbon and oxygen in the drawing chamber by means of the densitometers prior to the optical fiber drawing operation, so that an optical fiber without any variations in fiber diameter can be continuously produced.

[0037]

Furthermore, because a cooling device is installed in the housing chamber in order to cool the heated optical fiber preform, the heated optical fiber preform can be forcibly cooled by supplying the inert gas while the optical fiber preform in the drawing chamber is kept in the housing chamber during the operation of removing the optical fiber preform, so that safety can be improved, and the number of the operations can be reduced.

Brief explanation of the figures

Figure 1 is a diagram of the optical fiber drawing furnace pertaining to an application example of the present invention.

Figure 2 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 3 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 4 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 5 is a diagram of the optical fiber drawing furnace pertaining to another application example of the present invention.

Figure 6 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 7 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 8 is a diagram of the optical fiber drawing process using the drawing furnace.

Figure 9 is a diagram of the conventional optical fiber drawing furnace.

Reference numerals

| | |
|---|---|
| 11, 51 | drawing furnace |
| 12 | furnace main body |
| 13 | entrance |
| 14 | exit |
| 15 | core pipe |
| 16 | heater |
| 17 | shutter |
| 19, 20 | $CO$-$O_2$ densitometer |
| 21, 22, 52 | frame body |
| 27 | supply opening |
| 28 | exhaust opening |
| 29 | nitrogen gas supply system |
| 41 | optical fiber preform |
| 43 | optical fiber |
| A | drawing chamber |
| B | housing chamber |

Figure 1

Key: 19, 20 $CO$-$O_2$ densitometers

29 $N_2$ gas supply system

Figure 2

Key: 19, 20 CO-$O_2$ densitometers
29 $N_2$ gas supply system

Figure 3

Key: 19, 20 $CO$-$O_2$ densitometers

29 $N_2$ gas supply system

Figure 4

Key: 19, 20 $CO$-$O_2$ densitometers

29 $N_2$ gas supply system

Figure 5

Key: 19, 20 $CO-O_2$ densitometers
29 $N_2$ gas supply system

Figure 6

Key: 19, 20 CO-$O_2$ densitometers
29 $N_2$ gas supply system

Figure 7

Key: 19, 20 $CO$-$O_2$ densitometers
29 $N_2$ gas supply system

Figure 8

Key: 19, 20 CO-$O_2$ densitometers
29 $N_2$ gas supply system

Figure 9